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RAW SUGAR

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• Weight and Polarization Changes During Bulk Shipment from Puerto Rico

UNITED STATES DEPARTMENT OF AGRICULTURE
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Marketing Economics Division

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HIGHLIGHTS

Comparisons were made during 1957-60 between the weight and polarization of raw sugar when it was received at shipping terminals in Puerto Rico and when unloaded at mainland ports. The weight recorded at unloading was slightly lower than that recorded in Puerto Rico. The polarization was slightly higher.

The largest decline in weight, 0.606 percent, occurred in 1957 and the smallest, 0.260 percent, in 1959. The loss in 1960 was only slightly higher than in 1959. The gain in polarization during storage in Puerto Rican terminals and shipment to mainland ports ranged from 0.004 degrees in 1958 to 0.043 degrees in 1959.

The decline in value to producers in Puerto Rico from the weight and polarization changes in 1960 amounted to about $230,000; the total value of the sugar shipped to $91,000,000. The decline in 1960 was less than half of that in 1957.

The changes in weight and polarization could have occurred either while the sugar was in storage at the Puerto Rican terminals or during shipment to the mainland. The weight of the sugar at the time it was loaded on ships in Puerto Rico was available for only part of the shipments.

Weights at the time ships were loaded were obtained for 133 shipments made during 1958-59. These cargoes gained an average of 0.09 percent in weight and 0.013 degrees in polarization between loading in Puerto Rico and unloading at mainland ports. Fifty-one of the cargoes gained weight, 80 lost, and 2 showed no change.

Only 21 shipments, 16 percent of the total, had weight changes of 1 percent or more and only 5 shipments had a polarization change of 0.3 degrees or more. Most of the shipments with the largest weight changes were made from a single terminal.

Such changes in weight and polarization in sugar in transit from the island to mainland ports as occurred since 1957 have been decreasing in size. They are much smaller than similar changes that took place when raw sugar was shipped in bags. While slight further improvements in weighing and sampling procedures at both island and mainland ports may be possible, the cost of such improvements might easily exceed the benefits.

RAW SUGAR--WEIGHT AND POLARIZATION CHANGES DURING BULK SHIPMENT FROM PUERTO RICO

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INTRODUCTION

Bulk shipment of raw sugar from Puerto Rico began in 1947 with the opening of the first bulk shipping terminal. Previously, all shipments had been in bags. In 1955, a second bulk shipping terminal was placed in operation; then about one-fourth of the raw sugar produced in Puerto Rico could be shipped in bulk. In 1958 two more terminals were opened, and all Puerto Rican raw sugar was shipped in bulk. During this rapid transition from bagged to bulk handling, Puerto Rican raw sugar producers frequently complained of excessive weight losses during shipment.

Producers are paid on the basis of the weight and polarization of each cargo as determined at the unloading port. Weight and polarization usually change in transit. Terminals weigh and determine the polarization of all sugar as they receive it from the mills. Most sugar is stored at the terminal for a brief period (2 weeks or less) before being loaded on ships, although some moves directly to the ship. It was not possible to compare receiving weight at a terminal with the weight of sugar in individual shiploads, because the sugar is commingled in the terminal warehouses. However, the terminal warehouses are customarily emptied at the end of each shipping season. In this study, comparisons were made between the total weight and average polarization of sugar received at each terminal during the years 1957 through 1960, and the weight and polarization of the sugar received at mainland ports.

The purpose of this study was to determine the extent of the differences in weight and polarization in sugar from the time it was received at the port terminal and when it was received at the mainland refinery and to identify and determine the importance of the major factors accounting for the changes. The study does not include an analysis of changes in raw sugar during storage at mills where it is produced and during movement from mills to shipping terminals. Consequently, findings of this study are not fully comparable with those for shipment of bagged sugar reported in a previous study. 1/ It usually requires slightly over a week to move sugar from Puerto Rican terminals to mainland ports. The time is a little longer for large shipments. In the short period between the receipt of sugar at a terminal in Puerto Rico and its unloading at a mainland port, little change is likely to occur in the physical or chemical properties of sugar.

Each of the four raw sugar terminals in Puerto Rico cooperated by furnishing data showing the weight and polarization of sugar as received and of 133 shiploads when loaded at the terminal and when unloaded at a mainland port. The data for individual shipments covered all shipments made from January 1958 through October 1959. Data received from the Puerto Rican terminals were supplemented by observations of 13 shipments as they were loaded at the four terminals and again as

1/ Martin and Gilliland. Weight and Polarization Changes of Puerto Rican Raw Sugar in Storage and Shipment. Mktg. Res. Rpt. No. 220, Agr. Mktg. Serv., U. S. Dept. Agr. March 1958.

they were unloaded at three mainland ports, New York, Philadelphia, and Baltimore. Refineries with bulk receiving facilities at these ports cooperated by providing information on unloading schedules, access to unloading piers, weighing scales, sampling areas, sample mixing rooms, and other facilities used in unloading bulk raw sugar. Refinery personnel provided detailed information on weighing methods, scale testing, and clean-up procedures.

HANDLING BULK RAW SUGAR SHIPMENTS

The four bulk sugar loading terminals are located so as to serve all raw sugar mills in Puerto Rico. A fee is charged for sugar moving through the terminals. Only one terminal served as a warehouse to any significant extent. Usually sugar was loaded shortly after it arrived from the centrals where it was produced. Sometimes it moved directly to a ship without going through the warehouse. At one terminal title was taken to some of the sugar that moved through it. Changes in value resulting from changes in weight or polarization during shipment affect the income of raw sugar mills or cane growers.

Facilities for receiving, weighing, sampling, storing, and loading bulk raw sugar vary among the four Puerto Rican terminals. 2/ Each contains mechanical facilities for moving raw sugar in bulk from the terminal warehouse to the ship's hold and for weighing and sampling the sugar as it is being loaded.

Facilities for unloading bulk raw sugar at mainland ports were owned by the refineries. Movable unloading equipment was mounted on tracks on the pier to permit it to be moved to unload each hold of the ship. Two types of mechanism were in use, the "clam shell" bucket and the "marine leg" or gantry. The "clam shell" picked up 3 to 4 tons of sugar each time it was lowered into a ship's hold. This sugar was transferred to a conveyor belt system for movement to the scales.

The "marine leg," an enclosed upright continuous chain with attached buckets, was lowered into the holds of the vessel, from which position the sugar was elevated to a stationary conveyor belt system for movement to the weighing scales.

The sugar is weighed when unloaded with representatives of both the seller and the refiner in attendance to check the operation. The seller's representative also supervises the cleanup of the dock and the ship's holds. Sampling the sugar is done under the observation of employees of the testing laboratories who are paid by the sellers to represent them.

The most important feature of unloading is the thoroughness with which the ship's holds are cleaned. Inspections during or after the cleanup were made by both the seller's representative and the ship's captain. As unloading proceeded, stevedores cleaned the hull, ribs, and middle decks with long-handled scrapers and in some cases swept the bottom of the ship with brooms. Final cleaning was done with brooms and shovels.

Because of the caking of sugar in inaccessible points such as rib joints and between planks used for decking, some sugar is left in the holds. This was variously estimated at 200 to 500 pounds per hold. Assuming 500 pounds is left in each hold

2/ For a detailed description of each terminal see, Charles F. Denny, "Bulk Shipments of Raw Sugar from Puerto Rico," Sugar Report No. 83, Sugar Division, Commodity Stabilization Serv., U. S. Dept. Agr., Washington 25, D. C., March 1959.

of a 5-hold ship carrying 10,000 tons, there would be a weight loss of 0.0125 percent. After the vessels were unloaded, they were cleaned with water from hoses and there was little chance for sugar to be left in the holds and carried over to the next shipment.

WEIGHT AND POLARIZATION CHANGES THROUGH TERMINAL WAREHOUSES TO MAINLAND PORTS

Raw sugar is stored at the mills where it is produced until shortly before shipment to a mainland port. At this time it is moved to a shipping terminal where it is weighed, tested, and stored until time for loading on ship. It is necessary to maintain warehouse space at the dock since it is not possible to bring sugar from the mills and weigh it as fast as a ship can be loaded. Stored sugar enables the terminal to load a ship in the minimum time and therefore with minimum cost. Usually sugar does not remain in the terminal warehouse more than 1 or 2 weeks. Some sugar moves directly to the ship without going through the warehouse. However, it is weighed and tested as other sugar.

Sugar from different mills is mixed in the terminal warehouse; therefore, any losses or gains in weight or polarization incurred in moving sugar through the warehouse, and in shipping and unloading at mainland ports are prorated among mills on the basis of the weight and test as received at the warehouse. Each time sugar is moved there is likely to be some loss from spillage, sifting, and sticking to containers and equipment. These losses ranged from 0.11 percent from Aguirre terminal in 1960 to 0.74 percent at South Porto Rico in 1957 (table 1). Weight losses

Table 1.--Changes in weight and polarization of raw sugar shipped from Puerto Rican terminal warehouses to mainland ports, 1957-60

Kind of change, and terminal	1957		1958		1959		1960	
	Tons	Pct.	Tons	Pct.	Tons	Pct.	Tons	Pct.
Changes in weight:								
Aguirre	-898	-0.41	-499	-0.31	-549	-0.35	-165	-0.11
Aguadilla	N.A.	N.A.	-567	-0.448	-735	-0.282	-900	-0.328
South Porto Rico	-1,668	-0.741	-935	-0.531	-313	-0.243	-389	-0.340
San Juan	-841	-0.722	-676	-0.286	-470	-0.188	-417	-0.253
Total	-3,407	-0.606	-2,677	-0.387	-2,067	-0.260	-1,921	-0.266
	Degrees		Degrees		Degrees		Degrees	
Changes in polarization:								
Aguirre	+0.01		+0.05		+0.13		-0.05	
Aguadilla	N.A.		+0.15		+0.04		+0.05	
South Porto Rico	+0.056		-0.045		-0.016		+0.065	
San Juan	+0.023		-0.141		+0.018		-0.023	
All terminals	+0.029		+0.004		+0.043		+0.011	

N.A. - not available.

decreased at each terminal from 1957 through 1959 but increased in 1960 except at Aguirre where there was a further decline.

Each year there was a small gain in average polarization for all terminals, although some individual terminals showed small losses in polarization in 1958, 1959, and 1960. These changes in polarization probably were related to changes in the moisture content of the sugar. A decline in moisture would result in an increase in polarization unless offset by other factors.

The comparatively high weight losses in 1957 probably were the result of inexperience in the use of bulk handling equipment. These difficulties doubtless occurred at both loading terminals and mainland ports. The reduction in these losses from 1957 to 1959 indicates considerable improvement in operations.

WEIGHT AND POLARIZATION CHANGES OF INDIVIDUAL SHIPMENTS

Raw sugar producers are paid for their product on a basis of weight at unloading ports adjusted by premiums or discounts for sugar polarizing more or less than 96°. 3/ The effect of a weight change during shipment on the value of the sugar is offset to the extent that it is accompanied by a polarization change in the opposite direction. A 1-degree change in polarization has a slightly greater effect on the value of sugar than a 1-percent weight change.

Weight and polarization differences between loading at Puerto Rican terminals and unloading at mainland ports appear to be the result of several factors. A decline in weight may result from spillage of sugar in loading or unloading, adherence of sugar to the ship, a reduction in moisture content, overweighing when loading or underweighing when unloading. A gain in weight may result from an increase in moisture, or the weight may have been recorded inaccurately. Polarization changes may be caused by moisture changes, differences in the sample, or inaccurate analysis.

Significant changes in weight or polarization represent a financial gain or loss to the owners of the sugar depending on the direction of change. However, the gain or loss in weight for over two-thirds of the shipments was less than 0.5 percent (table 2). This is well within the limits of accuracy of at least one of the scales used to weigh sugar at shipping terminals in Puerto Rico. This scale was not rated as having an accuracy exceeding 98 to 99 percent. At the other extreme, two shipments gained and one lost more than 3 percent in weight.

Variations in polarization were much smaller than the changes in weight. Polarization changed by as much as one-half degree in only one out of 133 shipments. Nearly as many shipments gained as lost in polarization.

Differences in weight and polarization shown in table 2 are not comparable to those in table 1, since the data in table 1 are based on weights and polarizations at the time the sugar arrived at terminals, and that in table 2 on determinations made when the sugar was loaded on ships.

Weights determined at the time a ship is loaded may be somewhat less accurate

3/ For a detailed description of raw sugar pricing see "Bylaws and Rules, New York Coffee and Sugar Exchange, Inc., "Contract 6, Section 1, page 279. Some variation from the Exchange rules may occur for sugar testing over 98° polarization.

Table 2.--Change in weight and polarization of individual shipments of raw sugar from Puerto Rican terminal warehouses to mainland 1958-59

Amount of change	Gaining weight	Losing weight	Total
	Shipments	Shipments	Shipments
Change in weight:			
Less than 0.50%	1/ 29	63	92
0.50 to 0.99%	10	10	20
1.00 to 1.49%	3	2	5
1.50 to 1.99%	6	1	7
2.00 to 2.49%	2	1	3
2.50 to 2.99%	1	2	3
3.00% and over	2	1	3
Total	53	80	133
Change in polarization:			
Less than 0.10°	36	43	79
0.10° to 0.19°	14	19	33
0.20° to 0.29°	11	5	16
0.30° to 0.39°	2	2	4
0.40° to 0.49°	0	0	0
0.50° and over	1	0	1
Total	64	69	133

1/ Includes 2 cargoes that showed no change in weight.

than those recorded when the ship is unloaded or when sugar is received at a terminal in Puerto Rico because of the speed with which sugar is loaded. Also shipping weights ordinarily are used mainly to determine the amount of ocean freight due and are therefore less important to producers in Puerto Rico than unloading weights which are used as the basis for payment for the sugar, or arrival weights at the terminal which provide the basis for distributing sales receipts among producers.

A change of 1 percent in weight represents a change of about $12,000 in the value of a 10,000 ton cargo of sugar, based on the 1958-59 average prices and assuming no change in polarization. Since only 21 out of 133 shipments studied had a weight change as large as one percent and since most shippers owned sugar in more than one shipment, so that losses on some shipments might be offset by gains on others, weight changes were not an important problem for most shippers. Polarization changes were smaller and, therefore, were even less important.

Changes in weight and polarization in both years were opposite in direction and tended to offset each other slightly in their effect on the value of the shipments. The net effect of the changes, however, resulted in an increase in the value of the sugar of about $150,000 in 1958 and $40,000 in 1959. Weights in both years, calculated in terms of 96° equivalents, showed a slight gain. This indicates that more sucrose arrived at the mainland ports than was shipped from the Puerto Rican terminals--an obvious impossibility which probably is a result of small errors in determining weights and polarization.

RELATION OF CHANGES IN POLARIZATION TO CHANGES IN WEIGHT

Except for shipments which lost 0.5 percent or more in weight, there was a tendency for average changes in weight to be accompanied by much smaller changes in polarization in the opposite direction (table 3). Shipments losing 0.5 percent or more in weight had very little change in polarization.

One factor which might cause the polarization of a shipment of sugar to change in the opposite direction to a change in weight is the addition or loss of moisture. Added moisture would increase the weight of a cargo of sugar and decrease it polarization. If the added moisture were the only factor involved, polarization would decrease almost 1 degree for each 1 percent increase in weight. This did not happen, indicating that changes in moisture were of minor importance in accounting for the weight and polarization changes of Puerto Rican raw sugar during shipment.

Table 3.--Relation of weight changes to polarization changes in shipments of Puerto Rican raw sugar to mainland, 1958-59

Weight change	Shipments	Average weight change	Average polarization change
	Number	Percent	Degrees
-1.00% and over	7	-2.057	+0.004
-0.999 to -0.500%	10	-0.704	-.019
-0.499 to 0.000%	65	-0.221	+.047
+0.001 to 0.500%	27	+0.236	-.008
+0.501 to 1.000%	10	+0.710	-.050
Over 1.000%	14	+2.093	-.079
Total	133	+0.090	+0.012

VARIATIONS BETWEEN TERMINALS AND BETWEEN PORTS

Changes in weight of raw sugar shipped from the four terminals in Puerto Rico varied from an average gain of 0.627 percent for cargoes loaded at San Juan to a loss of 0.291 percent for those handled at Aguirre (table 4). Average polarization changes ranged from a decrease of 0.061 degree for shipments from San Juan to an increase of 0.105 degree for cargoes loaded at Aguirre. The percentage change in weight for shipments from the San Juan terminal was more than twice that of shipments from any of the other terminals, indicating that the weighing methods at San Juan may have been less accurate than those used at the other terminals.

Cargoes of raw sugar unloaded at Baltimore gained 0.481 percent in weight. This change was more than three times the average change in weight for cargoes unloaded at any of the other ports. About one-third of the shipments unloaded at Baltimore were loaded at the San Juan terminal in Puerto Rico.

Shipments of raw sugar from the Aguirre and Aguadilla terminals to all mainland ports except Baltimore had average weight losses during 1958-59 (table 4). Shipments from San Juan to all mainland ports showed average weight gains. With the exception of cargoes unloaded at Galveston, shipments from South Porto Rico also all registered average gains. Weight changes for shipments from San Juan, with the exception of those unloaded at Philadelphia, averaged considerably larger than those for cargoes shipped from the other three terminals.

Table 4.--Average changes in weight and polarization of raw sugar during shipment from Puerto Rican terminals to mainland ports, 1958-59

	Aguirre	Aguadilla	South Porto Rico	San Juan	Total
	Percent	Percent	Percent	Percent	Percent
Weight changes:					
New York	-0.356	-0.224	+0.034	+0.608	-0.062
Philadelphia	-.580	-.370	+.118	+.027	-.103
Baltimore	+.115	+.260	+.009	+.872	+.481
New Orleans	-.188	-.036	+.065	+.789	+.121
Galveston	-.943	-.007	-.550	+.075	+.132
Total	-.291	-.064	+.013	+.627	+.090
	Degree	Degree	Degree	Degree	Degree
Polarization changes:					
New York	+0.050	+0.015	-0.064	-0.014	+0.002
Philadelphia	+.197	-.006	+.017	+.012	+.044
Baltimore	+.157	+.045	-.072	-.088	+.016
New Orleans	+.077	-.013	-.068	-.201	-.007
Galveston	+.114	+.081	-.069	-.104	-.018
Total	+.105	+.024	-.030	-.061	+.012

Changes in the average polarization of shipments of Puerto Rican raw sugar when analyzed by shipping terminals and unloading ports were much smaller in nearly all cases than average weight changes. Shipments from Aguirre to all 5 unloading ports showed small gains in polarization, while those from South Porto Rico and San Juan showed average losses for all unloading ports except Philadelphia. Shipments unloaded at Philadelphia from all loading points except Aguadilla registered small gains in average polarization.

SHIPMENTS CHANGING ONE PERCENT OR MORE IN WEIGHT

Small changes in weight from shipping terminals to unloading port probably are unavoidable. It is doubtful, however, if a change as large as one percent should occur under normal operating conditions. However, approximately 16 percent of the shipments showed a change in weight of one percent or more. Of these, 14 gained and 7 lost weight (table 5).

More than two-thirds, 15 out of 21, of the shipments changing one percent or more in weight were loaded at San Juan. They were unloaded at all mainland ports, although Philadelphia received more than any other port. At the San Juan terminal the weights of some of the shipments were computed from the draft of the vessel. The accuracy of this method is questionable. The identity of the shipments from San Juan for which weights were estimated from ships draft is unknown, and consequently, it is not possible to determine if the shipments from San Juan with the largest changes in weight were those for which the weights at the Puerto Rican terminal were determined from ship's draft.

None of the cargoes loaded at Aguadilla, only 2 from Aguirre and 4 from South Porto Rico had weight changes of as much as 1 percent.

Table 5.--Shipments of raw sugar from Puerto Rico changing 1 percent or more in weight during shipment to mainland ports, 1958-59 1/

Puerto Rican terminal and mainland port	Total	Gaining weight	Losing weight	Percentage change in weight
	Shipments	Shipments	Shipments	Percent
Aguirre to:				
Philadelphia	1	0	1	-2.027
Galveston	1	0	1	-1.758
Total	2	0	2	-1.845
South Porto Rico to:				
Philadelphia	1	1	0	+1.616
New Orleans	1	1	0	+1.065
Galveston	2	1	1	-1.265
Total	4	3	1	+.122
San Juan to:				
New York	1	1	0	+4.254
Philadelphia	6	3	3	+.065
Baltimore	3	3	0	+2.108
New Orleans	2	1	1	+.744
Galveston	3	3	0	+1.796
Total	15	11	4	+1.188
Grand total	21	14	7	+.828

1/ No shipments from Aguadilla to any port, none from Aguirre to New York, Baltimore, or New Orleans, and none from South Porto Rico to New York or Philadelphia changed as much as one percent in weight.

Two of the shipments from San Juan lost over 4 percent in weight. The greatest weight loss for a shipment from South Porto Rico was in excess of 3 percent. The percentage gain of the 14 shipments gaining one percent or more in weight was approximately the same as the percentage loss of the 7 shipments losing weight.